DIVERSITY AND DISTRIBUTION OF DRAGONFLIES (SUBORDER: ANISOPTERA) WITH POTENTIAL AS BIOINDICATORS

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DECLARATION

The materials in this thesis are original except for quotations, excerpts, summaries and references, which have been duly acknowledged.

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ABSTRAK

Diversiti dan Taburan Pepatung (Suborder: Anisoptera) dan Potensinya sebagai Penunjuk Hayat

Kajian ini terbahagi kepada dua bahagian. Bahagian pertama adalah mengenai kajian komposisi dan kepelbagaian larva Odonata di Sg. Tabin, Sg. Urit and Sg. Lipad, Rezab Hidupan Liar Tabin, Lahad Datu, Sabah. Sejumlah 1405 individu larva Odonata yang mewakili 21 genus dan enam famili telah berjaya dikumpulkan. Famili Gomphidae didapati paling tinggi dalam bilangan taxon dan juga jumlah keseluruhan individu. Kesesuaian habitat, morfologi, tingkah laku dan adaptasi memainkan faktor penting yang mempengaruhi diversiti dan taburan Odonata. Diversiti dan taburan larva Odonata di antara sungai-sungai yang dikaji didapati berbeza secara signifikan. Kajian ini menunjukkan, kekayaan spesis bukanlah faktor tunggal yang patut diambilkira dalam memantau dan menilai sesebuah kawasan yang hendak dipelihara. Faktor geografi, ekologi, penempatan penduduk dan aktiviti persekitaran perlu diberi perhatian. Secara keseluruhannya, jenis substrat dan mikrohabitat merupakan faktor ekologi bagi pengelompokan sungai yang dikaji. Selain daripada itu, dari segi musim, didapati kualiti air dan kandungan nutrien menjadi faktor pengelompokan kumpulan sungai yang dikaji. Kesan perubahan musim ke atas spesis Odonata yang berbeza, adalah berbeza bergantung kepada keupayaan adaptasinya. Suhu, konduktiviti, DO, pH, turbiditi, halaju air, fosfat dan kalsium didapati mempengaruhi taburan larva Odonata. Bahagian kedua kajian ini adalah mengenai kepelbagaian dan taburan Odonata dewasa (Anisoptera) di seluruh Sabah. Sebanyak 17 lokasi dipilih untuk kajian ini. Sejumlah 2127 individu yang mewakili empat famili, 28 genera dan 40 spesis telah dikenalpasti. Daripada pengumpulan yang dibuat, sebanyak 17.55% adalah rekod baru bagi Sabah dan 97.5% adalah rekod baru bagi kawasan yang dikaji. Sebanyak 40.85% famili Libellulidae daripada diversiti Anisoptera Borneo telah direkodkan dalam kajian ini. Kajian ini telah menghasilkan senarai semak baru fauna Anisoptera bagi Sabah dengan 44 spesis. Rekod baru Anisoptera di Borneo dalam kajian ini telah berjaya mengemaskinikan senarai semak terdahulu dengan 149 spesis.

ABSTRACT

Diversity and Distribution of Dragonflies (Suborder: Anisoptera) with Potential as Bioindicators

This study is divided into two parts. The first part includes study on the composition and diversity of Odonata larvae which was carried out in Sg. Tabin, Sg. Urit and Sg. Lipad, Tabin Wildlife Reserve, Lahad Datu, Sabah. A total of 1405 individuals were collected comprising of 21 genera and six families of Odonata from the three studied rivers. The family Gomphidae was the highest in the total number of individuals and number of genera collected. The habitat suitability and the morphology, behavior and adaptability of odonates play an important factor in influencing their diversity and distribution. The diversity and abundance of Odonata larvae among the three studied rivers were significantly different. This study showed that besides species richness, factors such as geographical, ecological, human settlement and surrounding activities should be taken into consideration in monitoring or assessing the area that need to be conserved. Overall, it was found that types of substrat and microhabitat being an ecological factors grouping the cluster of rivers studied. As for the seasonal aspect, water quality and nutrients become factors that formed the clusters of river. Seasonal changes gave different effects on different species of odonates depending on their adaptability. Temperature, conductivity, DO, pH, turbidity, velocity, phosphate and calcium were found influenced the distribution of odonates larvae. The second part of this study is on diversity and distribution of adult Odonata in Sabah. Samplings were carried out in 17 chosen localities. A total of 2127 individuals representing 4 families, 28 genera and 40 species were identified from the sample collected. A revised checklist of Odonata (Anisoptera) was made for Sabah identified that 17.5% of species collected were new records for Sabah and an average of 97.5% species were newly recorded at the studied localities. The family Libellulidae contributed 40.85% of Borneon Anisopteran diversity. The present study produced 44 species as a new checklist of anisopterans fauna for Sabah. This study also manage to update the previous checklist of Anisoptera in Borneo with 149 species.

LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
ASPT	Average Score Per Taxa
BMWP	Biological Monitoring Working Party
cm	centimeter(s)
DO	dissolved oxygen
DOE	Department of Environment
FBI	Family Biotic Indices
g	gram(s)
ha	hectare(s)
hr	hour(s)
$\log_n$	natural logarithm to base *e*
m	meter(s)
mm	millimeter ($m \times 10^{-3}$)
NA	Not available
NIWQS	National Interim Water Quality Standards
NTU	Neophelometric Turbidity Units
pH	a measure of the hydrogen ion concentration in an aqueous solution
Sg.	Sungai
TDS	total dissolved solids
TWR	Tabin Wildlife Reserve
ULT	upper lethal temperature
USEPA	United States Environment Protection Agency
VJRs	Virgin Forest Reserve

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KEYWORDS

Anisoptera, larvae, adult, bioindicator, checklist.

CHAPTER 1

INTRODUCTION

1.1 What is Odonata

Dragonflies and damselflies are among the most glittering jewels of entomological world. They belong to the order Odonata (Hammond, 1983; Moore, 1997; Corbet, 1999; Orr, 2003), dragonflies from the suborder Anisoptera and damselflies from the suborder Zygoptera. Local vernacular name given to these spectacular insect are descriptive in nature. It is known locally by different ethnic group in Sabah such as "Pepatung"(Melayu), "Juli-juli"(Tidong), "Juru-juru", "Temperiding", "Bari-bari" (Bajau), "Sibu-sibu", "Tompo kiuk-kiuk"(Kadazan-Dusun) and "Petunding". Westfall and May (1996) pointed out that in Western cultures it is believed that this insect to have association with or resemblance to snakes or other reptiles ("snake doctor", dragonfly"), imagined dangerous properties ("horse-stinger") or associations with the devil ("devil's riding horse"; in Latin America often called "cabellitos del Diablo", i.e., "the Devil's little horses"). Other names may refer to their shape ("darning needle", "spindle"), behaviour ("mosquito hawk"), or graceful appearance ("demoiselle", "damselflies").

This order of insects have larvae living in waters and adults flying around. The adults are predators of a wide range of pests insect. The larvae have a voracious appetite for mosquito larvae. When placed in water containers that are potential mosquito breeding grounds, the larvae can be used as a biological control agent. While from the view point of anglers it is a good bait! According to Orr (2003), they have considerable potential as indicators of environmental disturbance following

logging or pollution, particularly as at different stages of their lives they occur in both freshwater and terrestrial habitats and may be sensitive to disturbances in either.

Both larvae and adults are predators and, as a result, a liable to concentrate any toxic pollutants that their prey (commonly other freshwater insects) accumulate. Thus, the fact that dragonflies depend on freshwater and other organisms that live in it means that their well being is inevitably linked to that of aquatic habitats. As Corbet (in Walker & Corbet, 1975) commented, it is important that freshwater remain able to 'sustain a diverse and vigorous dragonfly fauna – a reliable, and delightful, indicator of healthly environment' (Watson *et al.*, 1991).

1.2 Previous Study of Odonata

The study of Bornean dragonflies started around 150 years ago (Huisman & Van Tol, 1990). Due to large collections made in all parts, including the Kinabalu area with many endemic species, the Odonata fauna is relatively well understood. Nevertheless, intensive investigations in areas that were difficult to reach in the past have proved that still many species await discovery (Huisman & Van Tol, 1990).

Worldwide a total of around 5 500 species has been described and they are distributed from the tropics, where the greatest numbers and diversity occur, to the treeline in polar regions (Williams & Feltmates, 1992). There are only 11 species of odonates that occur in New Zealand and 194 species in the whole of Canada (Williams & Feltmates, 1992). In Malaysia, Bishop (1973) recorded 62 species from a single hill stream. During the Tabin Scientific Expedition and Inventory 1998, 25 species of dragonfly were documented from the Tabin Wildlife Reserve, Lahad Datu (Kitagawa *et al.*, 1999).

Moore (1997) stated that in order to minimize the effects on the fauna that depend on freshwater, those who frame decisions on the way that water is exploited, and the ways in which surrounding habitat are managed, detailed information on the organisms involved is needed. In the case of dragonflies, detailed knowledge of the fauna is required to understand their association with the environment they inhabit.

1.3 Odonata As Subject for Biological Research

There are also special, subsidiary reasons why dragonflies should be conserved. They are all connected with the fact that dragonflies are exceptionally large, day-flying insects. Their size has brought them to the attention of people throughout the world so that they have become part of the folklore of many countries, notably in China and Japan, where they are subject of poetry and painting (Moore, 1997). Their size makes them suitable subjects for biological research, especially for studies on behavior and ecology. As dragonflies are so easily observed they have considerable potential as bio-indicators. Some species are characteristic of particular habitats and so can be used for rapid mapping of the habitats that they represent. Dragonflies vary in their sensitivity to different type of pollution. Although they are less sensitive than some other aquatic insects, their conspicuousness makes them valuable for quick assessment of water quality. The number of species present on a lake or river can be compared with that of an unpolluted example of the same type. A count of dragonflies would provide a quick, and therefore low-cost, indication of the health of the lake or river (Moore, 1997) once key species have been recognized.

Odonata was chose in this study because they are unique, colourful and beautiful making it very attractive to be easily used as a model to educate people. Another reason why it was chose because of the differences in selected species diversity found in and around human settlements as compared to species found

around untouched area, more importantly their potential as biological indicator. While the larvae play a role as bioindicators of water quality, the adults are also suitable indicators of the environment.

The different development life stages and food requirement have also contributed in controlling insect vectors of dengue fever which breed in water containers (Sebastian *et al.*, 1990). Dragonflies therefore have a potential health and economic value which is not yet fully exploited. More importantly, the different life stages occur in different habitats play an important role as potential biological indicators. Therefore, more scientific research should be carried out, to explore more details on their association with the environment they inhabit.

1.4 An Outline of This Study

Two aspect were studied in this research. The first aspect, dealt with the larvae and their association with water quality. For this part, samplings were carried out in three rivers in Tabin Wildlife Reserve, Lahad Datu namely; Sg. Lipad, Sg. Urit and Sg. Tabin. It was hoped that the presence or absence of larvae of various species could be useful as an indicator of the water quality in accordance with one of the specific objectives purposes for which Tabin was established as a Wildlife Reserve is to protect the water catchment area of Tabin and it's scenic and aesthetic values for the benefit of the general public and the local people in particular (Sale, 1994). The second aspect investigated their distribution around Sabah, focusing only on the adult dragonflies. For this purpose, samples were caught manually using aerial net. Result of this aspect will update the checklist of Odonata (Anisoptera) in Sabah to the lowest taxa possible.

1.5 The Objective of Study

Furtado (1966) was the only person who worked on larval biotopes of riverine species and few other publications concentrated on the new species found in a couple of states in Peninsular Malaysia (Norma Rashid & Van Tol, 1995). There are at least 220 species of dragonflies and damselflies in Peninsular Malaysia alone (Lieftink, 1954). No compilation of Sabah and Sarawak odonates has been made, although Lieftink in 1954 has documented 259 species for the whole island of Borneo. Despite these many species occurring in this country, very little information has been published on the biological and ecological aspects of the Malaysian fauna. Therefore, it is hoped that, in this study the following objectives could be achieved:

i. to establish Odonata (Anisoptera) larvae as indicator of water quality

ii. to study the biodiversity and distribution of adults Odonata species in Sabah

iii. to update the checklist of Odonata (Anisoptera) in Sabah to the lowest taxa possible